

Chapter 4 Allowable Stress Design

4-1. General

HSS designed by the ASD method shall conform to specifications contained in AISC (1989), except as specified herein, and to the engineer manuals referenced in Appendixes B through I.

4-2. Design Basis

ASD is a method of proportioning structures such that allowable stresses are not exceeded when the structure is subjected to specified working loads. An elastically computed stress is compared to an allowable stress as represented by

$$f(\sum Q_i) \leq F_{\text{allow}} \quad (3-1)$$

where

$f(\sum Q_i)$ = elastically computed stress arising from the appropriately combined nominal loads

F_{allow} = allowable stress (yield stress, buckling stress, shear, net section tension, bearing strength, etc. divided by a factor of safety).

4-3. Load and Stress Requirements

a. Loads. Loads are divided into Group I and Group II loadings as follows:

Group I	
Dead load	Buoyancy load
Live load (serviceway)	Hydrostatic load
Thermal stress load	Operating equipment load
Ice loads (static)	
Group II	
Impact (vessel, debris, ice)	Water hammer
Wind loads	Ice loads (transient)
Wave loads	Operational basis earthquake (OBE)

(1) Ice loads may be considered as Group I (static load) or Group II (impact; short duration load) loads depending on circumstances.

(2) When the loading includes Group II loads acting alone or in combination with Group I loads, allowable stresses may be increased 1/3 above the values otherwise provided. However, the section thus provided shall not be less than that required for Group I loads when designed with the normal allowable stresses.

b. Stresses. It is considered necessary to reduce the allowable stresses given in AISC (1989) for HSS design (see commentary for paragraph 4-4 (paragraph 4-8)). Allowable stresses for three main types of HSS are specified in paragraph 4-4. Examples of each HSS type are discussed in the Commentary. If a structure has characteristics of more than one type, the lesser allowable stress is required.

4-4. HSS Types: Modifications for Allowable Stresses.

a. Type A. HSS which are used for emergency closures and which are subject to severe dynamic (hydraulic) loading or are normally submerged where maintenance is difficult, and removal of the HSS causes disruption of the project. For Type A HSS, the allowable stress shall be 0.75 times that allowed by AISC (1989).

b. Type B. HSS which are normally hydraulically loaded and are not subjected to unknown dynamic loading. For Type B HSS, the allowable stress shall be 0.83 times that allowed by AISC (1989).

c. Type C. HSS which are used for maintenance and are not considered emergency closures. For Type C HSS, the allowable stress shall be 1.1 times that allowed by AISC (1989). These allowable stresses are the maximum allowable values and may not be further increased due to Group II loading.

4-5. Serviceability Requirements

Guidance in paragraph 3-5 is applicable.

4-6. Fatigue and Fracture Control

Guidance in paragraph 3-6 is applicable.

4-7. Commentary on Paragraph 4-3, Load and Stress Requirements

a. ASD guidance for HSS considers Groups I and II loading, and Types A, B, and C stresses. The loading groups determine which conditions must stay within the modified AISC allowable stresses and which loading conditions are permitted a 1/3 increase in allowable stress. Because of the environment in which HSS are placed, modifications to AISC allowable stresses for HSS types are applied to increase the factor of safety above that which is used in building design.

b. Group I loads include those loads which are relatively constant for a significant time period, and Group II loads are those which vary with time. The 1/3 increase in allowable stress for structures subject to Group II loads acting alone or in combination with Group I loads is to account for the improbability of the simultaneous occurrence of maximum lifetime loads. Ice loads may be considered either Group I or Group II depending on the circumstances. If ice hanging on the structure is being considered as additional dead load or it is applying a lateral force due to expansion from thermal effects, it is considered a Group I load. If ice is acting dynamically on the structure due to wind or flowing water, it is considered a Group II load.

4-8. Commentary on Paragraph 4-4, HSS Types: Modifications for Allowable Stresses

a. In general, it is considered that HSS are subjected to more extreme environments and are subject to less predictable loads than are buildings. Variables listed in paragraph 3-8 (commentary of paragraph 3-4) are among the causes of this additional uncertainty. Therefore, an increase in the design factor of safety over that used for building design is considered necessary for HSS design.

b. The grouping by HSS type is a means to distinguish characteristics of different HSS. Type A is

considered to be the most extreme case, and Type C the least extreme case.

c. Type A includes those structures which are subject to unpredictable dynamic loading, or those which are normally submerged where maintenance is difficult. Unpredictable dynamic loading may occur as a result of hydraulic fluctuations in velocity and pressure due to abrupt changes in structure geometry or gate position as it is operated. Severe, unpredictable vibrations may also occur on structures subject to significant amounts of passing ice. Type A HSS include emergency gates, regulating gates where the structure passes through moving water under full pressure and flow conditions (unpredictable dynamic loading may occur), tainter and vertical lift crest gates used for regulation and subject to unknown dynamic hydraulic forces, and lock valves (normally submerged and difficult to maintain).

d. Type B includes structures for which dynamic loading is not significant and maintenance and inspection can be performed on a regular basis. HSS that may be classified as Type B include tainter crest gates, vertical lift crest gates, power intake gates designed for top of power pool, lock gates (miter gates, lift gates, and sector gates), and floodwall closures.

e. Type C structures include temporary closure items which are used to dewater for maintenance or inspection of gates, gate slots, and draft tubes. Stoplogs, bulkheads, draft tube gates, and bulkhead gates are included in this type. Such structures are not considered emergency closures and are usually opened and closed under balanced head conditions. The 1.1 factor applied to AISC (1989) allowable stresses reflects a 1/3 increase of the Type B allowable stresses. This increase is considered appropriate due to the fact that such structures are used on a temporary basis under essentially constant loading.